What is claimed is:

CLAIMS

1. A haptic feedback device for providing vibrotactile sensations to a user, said haptic feedback device coupled to a host computer and comprising:

a housing grasped by said user;

an actuator coupled to said housing; and

a mass, wherein said mass can be oscillated by said actuator, and wherein a coupling provided between said actuator and said mass or between said mass and said housing has a compliance that can be varied, wherein varying said compliance allows vibrotactile sensations having different magnitudes for a given drive signal to be output to said user grasping said housing.

2. A haptic feedback device as recited in claim 1 wherein said compliance is contributed by a magnetic spring provided between said actuator and said mass.

3. A haptic feedback device as recited in claim 2 wherein said actuator includes a magnet and a coil, and wherein said mass is coupled to a pivoting member, said pivoting member including at least one magnet that is moved by a magnetic field of said actuator.

4. A haptic feedback device as recited in claim 1 wherein said compliance is provided by a flexure coupling said mass to said housing.

5. A haptic feedback device as recited in claim 4 wherein said actuator is grounded to said housing and moves said mass which includes a magnet.

6. A haptic feedback device as recited in claim 5 further comprising a second grounded actuator, said second actuator providing a magnetic force on said mass to provide a variable tension in said flexure.

7. A haptic feedback device as recited in claim 1 wherein said compliance is provided by a flexible member coupled between said mass and said housing, wherein said actuator moves said mass using a magnetic field produced by said actuator.

8. A haptic feedback device as recited in claim 7 wherein said flexible member is a tapered member and is coupled to a rotary actuator that is coupled to said housing, wherein said

rotary actuator rotates said tapered member about its lengthwise axis to provide a variable compliance between said mass and said housing.

9. A haptic feedback device as recited in claim 7 wherein a compliance of said flexible member can be varied by moving a pair of grounded pincher rollers along a length of said flexible member.

10. A haptic feedback device as recited in claim 9 wherein said pincher rollers are moved by a second actuator coupled to said housing.

11. A haptic feedback device as recited in claim 1 wherein said haptic feedback device is a gamepad controller, said gamepad controller receiving information from said host computer which determines when said vibrotactile sensations are to be output based on events occurring within a graphical environment implemented and displayed by said host computer.

12. A haptic feedback device for providing vibrotactile sensations to a user, said haptic feedback device coupled to a host computer and comprising:

a housing grasped by said user;

a rotary actuator coupled to said housing; and

an eccentric mass coupled to and rotatable by said actuator about an axis of rotation, said eccentric mass having an eccentricity that can be varied relative to said axis of rotation while said mass is rotating, wherein varying said eccentricity allows vibrotactile sensations having different magnitudes for a given drive signal to be output to said user grasping said housing.

13. A haptic feedback device as recited in claim 12 further comprising a circuit for driving said actuator in two directions, said circuit receiving a drive signal and causing said actuator to oscillate said eccentric mass about said axis of rotation and induce a vibration in said housing.

14. A haptic feedback device as recited in claim 12 wherein said eccentric mass includes a plurality of discs slidably coupled to a rotating shaft that is coupled to said actuator, wherein a magnetic field is controlled to cause a desired number of said discs to frictionally engage with said shaft to provide a desired eccentricity of said mass.

15. A haptic feedback device as recited in claim 14 wherein said magnetic field is provided by a second actuator that includes a coil, a core, and a magnet, two ends of said core provided on either end of said shaft, and said magnet rigidly coupled to said shaft, wherein one of said discs engages said magnet and said other discs engage each other.

16. A haptic feedback device as recited in claim 12 wherein said mass includes a slotted member having a plurality of different slots radiating from a center aperture in said slotted member, at least two of said slots having a different length, wherein said actuator rotates a spindle having a keyed portion that engages in one of said slots to provide a desired eccentricity to said mass.

17. A haptic feedback device as recited in claim 16 wherein said spindle is coupled to a centering platen, said centering platen being moved by said actuator toward said slotted member to cause said slotted member to move such that said keyed portion is positioned in said center aperture of said slotted member, wherein said slotted member can then be rotated to allow said keyed portion to engage in a different one of said slots.

18. A haptic feedback device as recited in claim 16 further comprising a grounded kick foot, said kick foot moving said slotted member such that said keyed portion engages one of said slots.

19. A haptic feedback device as recited in claim 12 wherein said mass includes a ring magnet coupled to a hub, wherein a magnetic field is provided to move said ring magnet relative to said axis of rotation and relative to said hub to vary said eccentricity.

20. A haptic feedback device as recited in claim 19 wherein said magnetic field is provided by a coil and core coupled to said housing and positioned adjacent to said ring magnet, said hub being coupled to a rotating shaft of said actuator.

21. A haptic feedback device as recited in claim 12 wherein said mass includes a hopper that encloses a plurality of balls, and wherein an inlet to said hopper can be opened to allow additional balls to move inside said hopper and change a distance between a center of mass of said hopper and said axis of rotation, thereby change said eccentricity of said mass.

22. A haptic feedback device as recited in claim 21 wherein an outlet is provided in said hopper to allow one or more of said balls to leave said hopper, said outlet controllable by a separate controller.

23. A haptic feedback device as recited in claim 12 wherein said mass includes a rotating disc having a plurality of sockets, and wherein at least one ball can be pulled into one of said

sockets by a selective magnetic field, thereby changing a distance between a center of mass of said rotating disc and said axis of rotation to change said eccentricity of said mass.

24. A haptic feedback device as recited in claim 23 wherein said at least one ball is one of a plurality of balls provided in a groove, wherein a desired number of said balls can be pulled into corresponding sockets of said rotating member to provide a desired eccentricity of said mass.

25. A haptic feedback device as recited in claim 12 wherein said mass includes an arm member coupled to a rotating shaft of said actuator, wherein a member is pivotably coupled to said arm such that a different eccentricity is provided when rotating said arm in one direction than when rotating said arm in an opposite direction.

26. A haptic feedback device as recited in claim 12 wherein said haptic feedback device is a gamepad controller, said gamepad controller receiving information from said host computer which determines when said vibrotactile sensations are to be output based on events occurring within a graphical environment implemented and displayed by said host computer.

27. A method for providing vibrotactile sensations for an interface device coupled to a host microprocessor, the method comprising:

oscillating a mass with force provided by an actuator coupled to a housing of said interface device; and

varying a compliance of a coupling provided between said actuator and said mass or between said mass and said housing, wherein varying said compliance allows vibrotactile sensations having different magnitudes for a given drive signal to be output to said user grasping said housing.

28. A method as recited in claim 27 wherein said compliance is contributed by a magnetic spring provided between said actuator and said mass.

29. A method as recited in claim 27 wherein said compliance is provided by a flexure coupling said mass to said housing.

30. A method as recited in claim 29 wherein said actuator moves said mass using a magnetic field produced by said actuator.

31. A method for providing vibrotactile sensations for an interface device coupled to a host microprocessor, the method comprising:

rotating an eccentric mass about an axis of rotation with force provided by an actuator coupled to a housing of said interface device; and

varying an eccentricity of said eccentric mass relative to said axis of rotation while said mass is rotating, wherein varying said eccentricity allows vibrotactile sensations having different magnitudes for a given drive signal to be output to said user grasping said housing.

32. A method as recited in claim 31 further comprising a circuit for driving said actuator in two directions, said circuit receiving a drive signal and causing said actuator to oscillate said eccentric mass about said axis of rotation and induce a vibration in said housing.

33. A method as recited in claim 31 wherein said varying an eccentricity includes using a magnetic field to cause a plurality of rotating discs to frictionally adhere to each other..

34. A method as recited in claim 31 wherein said varying an eccentricity includes moving a rotating keyed portion into a slot of a slotted member, said slotted member having a plurality of different slots radiating from a center aperture in said slotted member, at least two of said slots having a different length.

35. A haptic feedback device as recited in claim 31 wherein said mass includes a ring magnet coupled to a hub, wherein a magnetic field is provided to move said ring magnet relative to said axis of rotation and relative to said hub to vary said eccentricity.

36. A haptic feedback device as recited in claim 31 wherein said mass includes a hopper that encloses a plurality of balls, and wherein an inlet to said hopper can be opened to allow additional balls to move inside said hopper and change a distance between a center of mass of said hopper and said axis of rotation, thereby change said eccentricity of said mass.